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Enclosed are:

- [X] Specification, Claim(s), and Abstract (21 pages).
- [X] Informal drawings (6 sheets, Figures 1-9).
- [X] Unsigned Declaration and Power of Attorney (4 pages).
- [X] Claim for Convention Priority and Priority Document.
- [X] Information Disclosure Statement.
- [X] Form PTO-1449 with copies of 1 listed reference(s).

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GAS RECLAIMING EQUIPMENT

BACKGROUND

Field of the Invention

The present invention relates to gas reclaiming equipment used for gas insulated equipment filled with an insulating gas, and more particularly to gas reclaiming equipment adapted for gas-insulated equipment filled with environmentally problematic gasses such as SF₆/nitrogen insulating gas mixtures.

Description of the Related Art

Generally, a substation has a circuit breaker and a disconnecter to perform a system change and a maintenance check. In particular, large-sized equipment from among the above mentioned equipment use gas insulated equipment filled with SF₆ gas is especially adopted.

Generally, SF₆ gas is highly desirable because of its insulation performance and arc interruption performance. Moreover, since SF₆ gas is a chemically stable and harmless gas, it has been widely adopted as an insulation medium in the above-mentioned equipment. However, SF₆ gas contributes to the greenhouse effect and has a long decomposition life.

Because of environmental protection concerns over a long period of time, the exhaust of SF₆ gas is regulated. Therefore, when performing periodic inspection and parts exchange, the SF₆ gas should be reclaimed so that it does not leak to the outside from the gas insulated equipment.

When reclaiming and storing the SF₆ gas, a large-size tank for storing the SF₆ gas is necessary as the volume of the SF₆ gas gets large. However, it is advantageous to change the gas into a high-pressure state and to reduce the volume of the SF₆ gas. This, however, may generate safety problems.

Accordingly, it has been proposed to use gas reclaiming equipment that converts the SF₆ gas to SF₆ liquid by pressurization and liquefaction of SF₆. By using such equipment, the tank for reclaiming can be greatly reduced. Furthermore, the safety can be improved.

Figure 1 shows a basic structure of the gas reclaiming equipment. The gas reclaiming equipment is used for reclaiming the gas from gas insulated equipment 1. The gas reclaiming equipment consists of a filter 2, a vacuum/compression pump 3, a gas liquefaction system 6, an SF₆ liquid tank 7, a refrigerator 11, and a cooling pipe 12.

The gas-insulated equipment 1, the filter 2, the vacuum/compression pump 3, the gas liquefaction system 6, and the SF₆ liquid tank 7 are connected to each other through a pipe 13. A valve 14 for controlling the flow rate from the gas liquefaction system 6 or the SF₆ liquid tank 7 is provided. In addition, the filter 2 adsorbs decomposed gas of SF₆, which occurs due to an arc. The filter also absorbs particulate foreign substances.

SF₆ gas with high-purity and high-dryness is required for the gas insulated equipment 1. Therefore, an adsorbent is used for the purpose of removing moisture or decomposed gas. As the adsorbent, Zeolites with a pore size of approximately 5Å or 10Å are commonly used, since the decomposed gas molecules are larger than a molecule of H₂O. Even, Zeolites with pore size of 9Å can be used. That is, the size depends on what kind of gas is being reclaimed.

In a conventional gas reclaiming equipment, the SF₆ gas is sent into the gas liquefaction system 6 from the gas insulated equipment 1 through the vacuum/compression pump 3. Additionally, a refrigerant, like chlorofluorocarbon, is sent through the cooling pipe 12 from the refrigerator 11. The SF₆ gas is liquefied in the gas liquefaction system 6 and then the reclaimed SF₆ liquid is stored in liquid tank 7.

If moisture, and various decomposition gases (HF, H₂O, SO₂ and SOF₂, SO₂F₂), and a related gas molecule (CF₄), are put in order in terms of the largest to smallest adsorption power, the order could be shown below:

HF, H₂O, SO₂ and SOF₂, SO₂F₂, CO₂, SF₆, CF₄, N₂, O₂

In the above-mentioned list, the reactivity of HF is the highest and HF is chemisorbed. Its adsorption energy is about 100kcal/mol. It is believed that the rest of the gasses are absorbed by physisorption. The adsorption energy in physisorption is approximately 1-4 kcal/about mol.

5 Compared with chemisorption, physisorption is weaker in terms of adsorption. So, it is believed that gas molecules de-sorb from the adsorbent under the influence of molecular movement in a reduced pressure state. In addition, even if the molecule with weak adsorption is adsorbed by physisorption, when a molecule with strong adsorption arrives, the molecular with strong adsorption adsorbs such that the molecule with the strong adsorption replaces the molecule with weak adsorption.

10 Among these gases, it is hard to de-sorb moisture under reduced pressure. However, under a reduced pressure state for reclaiming SF₆ gas, gases such as SOF₂, SO₂F₂, CO₂, SF₆, CF₄, N₂, and O₂ de-sorb from the adsorbent. Therefore, gases such as SOF₂, SO₂F₂, CO₂, SF₆, CF₄, N₂, and O₂ may discharge from the gas insulated equipment 1, and may go into the reclaiming equipment. If so, the filter 2 catches the decomposed gas and any foreign substances, and prevents invasion of the decomposed gas and foreign substances into the gas liquefaction system 6.

For when the earth's environment, the quantity of discharged SF₆ gas needs to be reduced further. For that purpose, it is desirable to reduce the quantity of SF₆ gas used.

20 The use of mixed gas, having nitrogen gas as a main component and a little SF₆ gas, is considered to be effective in the curtailment of SF₆ gas. However, the properties of SF₆ gas and nitrogen gas differ remarkably. That is, under the conditions in which SF₆ gas liquefies, nitrogen gas does not liquefy simultaneously. Nitrogen still exists as a gas. Therefore, it is possible to liquefy only SF₆ gas in a mixed gas and to separate SF₆ gas from nitrogen gas.

25 The characteristic values of mixture ratio and liquefaction pressure are shown in Table 1.

Table 1

Mixture ratio	Liquefaction pressure
100 vol % SF ₆ gas	2 Mpa
50 vol % SF ₆ gas	4 Mpa
10 vol % SF ₆ gas	More than 20 Mpa

If the purity of SF₆ gas is high, the pressurization liquefaction of SF₆ gas is easy at room temperature, such as 20 degrees C. However, in order to liquefy SF₆ gas in a mixed gas, high pressure is needed.

As shown in Table 1, since a pressure of 20 Mpa or more is needed at room temperature, the liquefaction of SF₆ is very difficult in the case of 10vol% SF₆ gas. Moreover, large-sized refrigeration equipment needs to be used and the liquefaction pressure needs to be lowered. Consequently, the enlargement of equipment has become a problem in reclaiming and recycling mixed gas.

Gas reclaiming equipment is disclosed in Japanese Patent Disclosure (Kokai) No.2000-135412. However, there are the following problems with the conventional technology of reclaiming mixed gases containing SF₆ gas. That is, when a mixed gas is incorporated into the gas liquefaction system 6 and the gas liquefaction system 6 liquefies SF₆ gas continuously, the following problem occurs.

The concentrated SF₆ gas is liquefied in the gas liquefaction system 6, but the main composition gas, such as nitrogen gas, of the mixed gas continues to accumulate in the gas liquefaction system 6. Therefore, before exceeding the design pressure of the gas liquefaction system 6, this main composition gas needs to be extracted from the gas liquefaction system 6.

However, the main composition gas may contain some SF₆ gas, and thus the main composition gas cannot be emitted into the atmosphere. Therefore, in order to prevent the SF₆ gas from remaining in the main composition gas, the reclaiming ratio of SF₆ gas is preferably improved. Moreover, in considering reclaiming the mixed gas, the gas pressure in the gas-

insulated equipment is high early in the reclaiming stage. Therefore, the gas automatically flows into the reclaiming equipment side by only opening a valve. As a result, adjusting the flow rate is easier.

However, in the case when the reclaiming work has been performed, the reclaiming work under reduced pressure becomes necessary. The reclaiming work depends on the capability of the vacuum/pressurization pump. The processing quantity per unit time is reduced under reduced pressure. Therefore, it becomes difficult to secure a sufficient flow rate and the reclaiming efficiency is lowered.

Furthermore, when gas is forcibly extracted with the vacuum/pressurization pump, decomposed gas de-sorbs from the adsorbent in the gas insulated equipment beforehand. Therefore, the decomposed gas will be discharged into the reclaiming equipment side.

If the decomposed gas enters the reclaiming equipment, the life of the reclaiming equipment is adversely affected. Decomposed gas causes, for example, chemical degradation of the pipes in the reclaiming equipment and degradation of the material of the adsorbent.

Therefore, it is desirable that the decomposed gas discharged from the gas insulated equipment be captured with certainty. Moreover, as mentioned above, in the gas insulated equipment, an adsorbent having various Zeolites, for example Zeolites with 5Å or 10Å pores, is usually enclosed.

At this time, the adsorbent includes Zeolites with approximately 10Å pores which adsorbs SF₆ gas for reclaiming. Therefore, if there is a high quantity of the adsorbent, when reclaiming in a reduced pressure condition, the SF₆ gas will de-sorb from the gas insulated equipment side gradually for a long period of time. Therefore, there is a problem in that the reclaiming of SF₆ gas takes a long time. On the other hand, if the adsorbent material has Zeolites with a size of 5Å, it is difficult to adsorb a decomposed gas larger than 5Å in size, and the rate of absorption may decrease.

Therefore, optimization of the combination of Zeolites in the adsorbent in the gas-insulated equipment is desired.

SUMMARY OF THE INVENTION.

The present invention has been made in view of the above-mentioned circumstances and is intended to solve the above-mentioned problems. In particular, the object of the present invention is to provide a gas reclaiming equipment having a simple and inexpensive structure, and capable of reclaiming SF₆ gas with high efficiency.

The present invention provides a gas reclaiming equipment including: a filter for removing a decomposed gas and particulate foreign substances from a mixed gas which is sent from the gas insulated equipment; a pump for sending the mixed gas from the gas insulated equipment to the gas liquefaction system; a gas liquefaction system for reclaiming the mixed gas, wherein the gas liquefaction system liquefies the SF₆ gas of the mixed gas by pressurizing the mixed gas; a storage tank for accumulating a SF₆ liquid obtained by the gas liquefaction system; and a line for returning a gas phase in the gas liquefaction system to a upstream side of the gas liquefaction system.

BRIEF DESCRIPTION OF DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several preferred embodiments of the present invention and, together with the description, serve to explain the principles of the present invention.

Fig. 1 is a diagram showing a basic structure of conventional gas reclaiming equipment.

Fig. 2 is a diagram showing gas reclaiming equipment according to a first embodiment of the present invention.

Fig. 3 is a diagram showing the gas separation principle according to the first embodiment of the present invention.

Fig. 4 is a graph showing the relationship between the equilibrium adsorption and the pressure for a zeolite.

Fig. 5 is a detailed diagram showing the gas reclaiming equipment according to the first embodiment of the present invention.

Fig. 6 is a graph showing the adsorption characteristics of a Zeolite.

Fig. 7 is a diagram showing the gas reclaiming equipment according to a second embodiment of the present invention.

Fig. 8 is a diagram showing the gas reclaiming equipment according to another embodiment of the present invention.

Fig. 9 is a diagram showing an embodiment of the invention with plural gas separation units.

Fig. 10 is a diagram further explaining the gas separation principle.

DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of gas reclaiming equipment of the present invention are now specifically described in more detail with reference to the accompanying drawings. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or like parts.

Fig. 2 is a diagram showing gas reclaiming equipment according to a first embodiment of the present invention. Gas separation equipment 5 is provided between gas insulated equipment 1 and a gas liquefaction system 6. The gas separation equipment 5 separates nitrogen gas from mixed gas, and concentrates the SF_6 gas. Thereafter, only SF_6 gas is sent into the gas liquefaction system 6.

The gas separation equipment 5 includes pressure swing adsorption using an adsorbent with selective adsorption. Moreover, a buffer tank 4, which stores the mixed gas temporarily,

is provided between the gas separation equipment 5 and the gas insulated equipment 1. The buffer tank 4 is operated on the condition that the inside of the buffer tank is pressurized at all times.

The buffer tank 4 and the gas liquefaction system 6 are connected by a reflux-line 19. The reflux-line 19 refluxes the gas in a gas-phase from the gas liquefaction system 6 to the buffer tank 4. The gas-phase contains a very small quantity of SF₆ gas which is equivalent to the vapor pressure of SF₆. Furthermore, the gas separation equipment 5 is connected to a storage tank 8 for exhaust gas. The storage tank 8 accumulates the nitrogen gas separated through the gas separation equipment 5.

The adsorbent 18 having approximately 10Å Zeolites for adsorbing SF₆ gas is enclosed in the storage tank 8 for the exhaust gas. A filter 2 having an adsorbent 2a of the chemisorption type to absorb decomposed gas is interposed between the gas insulated equipment and a pump 3. The adsorbent 2a has a metal hydrate, such as Ca(OH)₂. The above components are connected with the pipe 13. A valve 14 controls the flow.

Operation of the first embodiment will now be described. First, the separation principle of gas in the gas separation equipment 5 is explained by reference to Fig. 2, Fig. 3, and Fig. 4 and Fig. 10.

The Zeolites shown in Fig. 3, used as the adsorbent, are enclosed in the gas separation equipment 5. Zeolites are a generic name for crystalline aluminosilicates of alkali. The general formula of Zeolites is shown by MeO• Al₂O₃• mSiO₂• nH₂O. Moreover, Zeolites have uniform pores on their surface.

Since only a molecule smaller than the pore can pass along a narrow pipe of Zeolites, the molecule can be adsorbed inside, as illustrated in Fig. 10. The pores in the Zeolite act like small holes while the molecules of SF₆ and nitrogen gas act like small balls. The "balls" of the same size as the pores get stuck in the pores. This illustrates the outstanding selective adsorption, or molecular sieve effect.

On the one hand, SF₆ gas and nitrogen gas differ from each other in molecular size. The size of the SF₆ molecule varies from DS5.49 - DL6.06, and the size of the nitrogen molecule varies from DS3.1 - DL4.2. The unit of size is Å. DS shows the shorter parameter of the molecule. DL shows the longer parameter of the molecule. Molecular size is described with DS and DL because of its non-spherical shape.

When using Zeolite with a pore-diameter of 5 Å, SF₆ gas is not adsorbed. This is because SF₆ gas is larger than the pore in the Zeolite surface. Nitrogen gas is adsorbed alternatively, and separation of SF₆ gas is provided.

Zeolites have a metal cation in the crystal structure. The metal cation attracts a polar group by static electricity, or a neutral molecule electrically by polarization. Thus, it is believed that the metal cation is widely applicable based on the above mentioned reason.

The gas separation equipment 5 separates the mixed gas with Zeolites by the selective adsorption mentioned above using the pressure swing adsorption method. The basic principle of the pressure swing adsorption method is that the adsorption quantity of the adsorbent is proportional to the gas pressure. Fig. 4 is a graph showing the relationship between the adsorption quantity and pressure.

Fig. 5 is a detailed diagram showing a main part of the gas separation equipment 5. That is, the gas separation equipment 5 has two adsorbent vessels 15a and 15b. An adsorbent 16 with 5 Å Zeolites is contained in the two adsorbent vessels 15a and 15b.

The fundamental run pattern of valves B1, B2, B3, B4, B5, B6 and B7 will now be explained. Valves B1 and B4 are open, and the other valves are closed. Moreover, valve B4 is combined with the vacuum/compression pump 3 on the condition that valve B4 is open, and reduced pressure processing is carried out.

First, separation of SF₆ gas will be explained. The mixed gas in the gas insulated equipment flows to a down-stream side with the vacuum/compression pump 3, through the

buffer tank 4. The mixed gas flows into the adsorbent vessel 15a in the gas separation equipment 5.

At this time, the adsorbent vessel 15b is controlled by the vacuum/compression pump 3 under reduced pressure. It is in the early regeneration state and emits the adsorbed nitrogen gas. In the adsorbent vessel 15a, the adsorbent adsorbs only nitrogen gas by the molecular sieve effect. On the one hand, SF₆ gas flows along the upper part, along the flow route, raising its concentration. Finally, gas with high SF₆ gas concentration accumulates on the upper part of the adsorbent vessel 15a.

When the pressure in the adsorbent vessel 15a gets to a predetermined pressure, inflow of mixed gas is stopped, by closing the valve B1, and SF₆ gas concentrated by opening valve B6 is reclaimed. In addition, for better efficiency and stability, values within the limits at 0.2-0.5MPa are usually used.

Subsequently, while valve B6 is closed, the flow route of mixed gas is changed into the adsorbent vessel 15b side by opening valve B3. Thus, SF₆ gas will be separated and concentrated in the adsorbent vessel 15b. First, reduced pressure processing in the adsorbent vessel 15a side is carried out, and the nitrogen gas de-sorbs. While the nitrogen gas is discharged by opening valve B2, the adsorbent 16 will be in the initial state before the adsorbent starts adsorbing.

By repeating the above-mentioned operation, mixed gas is separated into SF₆ gas and nitrogen gas. SF₆ concentrated gas is then sent into the gas liquefaction system 6.

As mentioned above, only nitrogen gas smaller than the pore diameter of the adsorbent 16 can be adsorbed during the adsorption process using high pressure. If the pressure is reduced in the adsorption process, the nitrogen gas currently adsorbed to the adsorbent 16 will de-sorb, and, finally nitrogen gas will be discharged. Furthermore, the adsorbent 16 will be in the initial state simultaneously through this operation. Then, again, when the gas pressure increases, the same quantity of nitrogen gas discharged can be absorbed. Thus, a repeating

operation of absorption and regeneration makes semi-permanent separation of the mixed gas possible.

However, as mentioned above, the initial performance deteriorates gradually due to the strong bonding of moisture and decomposed gas with the adsorbent 16. In such a situation, in order to prevent mixing of the decomposed gas, a designated purity control needs to be carried out. The gas flowed into the reclaiming equipment should be controlled.

As mentioned above, if the initial SF_6 gas concentration is 10 vol % - 50 vol % of the mixed gas, the liquefaction pressure will be set to about 4 MPa at room temperature. Therefore, the existing liquefaction equipment can be used and the risk of liquefaction under high-pressure is also decreased remarkably. Moreover, even though the liquefaction may be performed by using cooling, the increase in size of the equipment is avoidable.

For example, at 20 degrees C, the liquefaction pressure can be reduced up to about 1.3 MPa. Moreover, even if pressure of the gas insulated equipment 1 is reduced in the reclaiming process and the flow rate of mixed gas decreases, mixed gas can be accumulated in the buffer tank 4 temporarily. Therefore, the operation after the gas separation equipment 5 can be stopped, and sufficient flow rate and amount of mixed gas put into the gas separation equipment 5 can be secured by gas accumulation into the buffer tank 4. That is, the appropriate gas flow rate under the reduced pressure condition can be realized, and high reclaiming efficiency can be maintained.

In addition, when the quantity of gas runs short in the buffer tank 4, the reclaiming operation can be stopped and the valves closed. The remaining reclaiming process can then be carried out at the following gas reclaiming operation for another gas insulated equipment. Reduced pressure processing is unnecessary in the buffer tank 4 for the above reason.

On the other hand, the decomposed gas contained in the mixed gas does not de-sorb. Furthermore, in the first embodiment, the adsorbent 2a of the chemisorption type in the filter

2 catches the decomposed gas with certainty. Therefore, the decomposed gas is mixed neither into the gas separation equipment 5 nor the gas liquefaction system 6.

Therefore, the performance degradation related to chemical factors and physical factors does not occur. Thus, the lifetime of the equipment can be prolonged. Moreover, though a very small quantity of SF_6 gas remains in the nitrogen gas separated with the gas separation equipment 5, the adsorbent 18 in the storage tank 8 for exhaust gas adsorbs only SF_6 gas. The same effects can be obtained using a column containing the adsorbent 18 instead of the storage tank 8.

Fig. 6 shows the change of SF_6 gas concentration of a mixed gas with 5% SF_6 gas at a pressure of 0.2MPa when using an adsorbent comprising 10Å Zeolites. Fig. 6 shows that the adsorbent also adsorbs a very small quantity of SF_6 gas with certainty. In addition, SF_6 gas adsorption with an adsorbent 18 having the 10Å Zeolites become saturated. Therefore, after the predetermined quantity processing of SF_6 gas, while SF_6 gas is reclaimed under the reduced pressure, the adsorbent 18 needs to be restored into its initial condition.

In this case, the vacuum/compression pump 3 sends the mixed gas having nitrogen gas, which is the main ingredient, and SF_6 gas into the buffer tank 4, through the piping 13. Moreover, experiments show that the adsorption power of the adsorbent is in inverse proportion to temperature. That is, if temperature is lowered, SF_6 gas adsorbed to the Zeolites increases. On the one hand, SF_6 gas remaining in the gas phase decreases.

In other words, if the temperature is raised, the adsorption power will decline, and if the temperature is lowered, the adsorption power increases. That is, when the reproducing of the adsorbent is required in a short time, it is better that the temperature is at 80-100 degrees C.

Since the separation reclaiming is carried out, almost all discharge to the atmosphere of SF_6 gas can be reduced to the appropriate discharge level. Thus, the discharge level shows outstanding environmental harmony.

Moreover, as shown in Fig. 6, according to the experiment, it is ascertained that SF₆ gas can be adsorbed by supplying discharge gas into an adsorbent vessel filled with an adsorbent 18 of 10Å Zeolites. In this case, if the reduced pressure processing is carried out at a gas exit side, SF₆ gas will disperse to the adsorbent in a non-adsorbed portion. Therefore, it is better to perform the reduced pressure processing and to reproduce the adsorbent from the gas entrance side of the column (not shown) provided in the storage tank 8 for exhaust gas. Therefore, it is not necessary to supply a trap at the buffer tank 4. That is, the same effect as the mentioned effect can be attained by flowing the exhaust gas to the adsorbent vessel, filled with the adsorbent 18 having 10Å Zeolites.

As mentioned above, in the first embodiment, the gas separation equipment 5 separates mixed gas into SF₆ gas and nitrogen gas. In this separation operation, preventing SF₆ gas mixing into nitrogen gas as much as possible is desirable. For this reason, when sending SF₆ gas reclaimed in the gas separation equipment 5 to the pump 3, SF₆ gas is also reclaimed by supplying the nitrogen gas together.

In this case, if the nitrogen gas is reclaimed continuously, SF₆ gas and the nitrogen gas continue to accumulate in the gas liquefaction system 6. In other words, although SF₆ gas is liquefied by the gas liquefaction system 6, the nitrogen gas continues to accumulate gradually in the gas state. Therefore, the pressure in the gas liquefaction system 6 may exceed the design pressure.

To prevent this problem, in the first embodiment, nitrogen gas can be returned to the buffer tank 4 from the gas liquefaction system 6 through the reflux-line 19. Thereby, an improvement in safety is obtained. Further, the reclaiming efficiency of SF₆ gas improves sharply by passing this gas again through the gas separation equipment 5 and the gas liquefaction system 6, even though SF₆ gas remains mixed in the nitrogen gas. Therefore, in the reclaiming SF₆ gas, the discharge of SF₆ gas to the atmosphere can be ignored.

In addition, the same effect as mentioned above can be achieved by keeping nitrogen gas in another container temporarily and returning it to the gas separation equipment 5, instead of returning the nitrogen gas through the reflux-line 19 automatically.

A second embodiment is shown in Fig. 7 and Fig. 8. The second embodiment encloses an adsorbent 16 with 5Å and 10Å Zeolites in the buffer tank 4.

In Fig. 7, two buffer tanks 4a and 4b are provided. Furthermore, the adsorbent 16 is enclosed only within the buffer tank 4b. In this embodiment, the pressure of the mixed gas is reduced by controlling the valve 14, and mixed gas is reclaimed. The buffer tanks 4a and 4b, having the adsorbent 16, serve so that the mixed gas may be stored.

According to this embodiment, the adsorbent 16 enclosed in the buffer tank 4b can reliably catch the decomposed gas which passes through the filter 2. Furthermore, the decomposed gas does not mix in the gas separation equipment 5 or the gas liquefaction system 6. Therefore, it is possible to prevent the chemical degradation and physical degradation and to prolong the lifetime of the equipment.

Only when the mixed gas is reclaimed under the reduced pressure, can the mixed gas be stored in the buffer tanks 4a and 4b. Further, the mixed gas can only be passed under a designated pressurization state through the buffer tanks 4a and 4b to an atmospheric pressure.

Therefore, at the beginning of the reclaiming work, with the high gas pressure of the gas-insulated equipment 1, the mixed gas can be reclaimed quickly, and shortening of reclaiming work hours can be attained. Moreover, since an adsorbent 16 with 5Å and 10Å Zeolites is used, the quantity of the adsorption of SF₆ gas can be suppressed. Furthermore, it is possible to adsorb a molecule larger than 5Å quickly from the decomposed gas.

In addition, it is good not to perform the reduced pressure processing in the buffer tanks 4a and 4b, but to perform an operation-stop in the state where a pressure has slightly been applied. That is, it can prevent the decomposed gas from de-sorbing from the adsorbent by applying a pressure within about 0.1-0.2 Mpa, for a while. Furthermore, a film for the gas

separation equipment, as another embodiment, can be used. That is, the thing adapting the difference of the dissolution to a molecular size, a film material for example, can be considered. A film material made from a macromolecule can be used as an example.

Even, as a further embodiment, the gas reclaiming equipment can have plural gas separation units. This embodiment is illustrated in Fig. 9. For example, in the first place, the mixed gas is led to a 1st gas separation unit 21, and the 1st step gas separation unit 21 reclaims concentrated SF_6 gas. Then, gas discharged from the gas reclaiming equipment is led to a 2nd gas separation unit 23. The 2nd step of the gas separation unit 23 again concentrates SF_6 gas contained in a very small quantity.

According to this embodiment, SF_6 gas with high purity and the reduction of the liquefaction pressure of SF_6 gas can be attained by performing plural gas separation processes. Moreover, another embodiment relates to the gas insulated equipment side for making gas reclaiming easy. In this embodiment, an adsorbent with 5Å and 10Å Zeolites is enclosed as a decomposed gas removal material and a desiccant in the gas insulated equipment 1. As the object for the dryness in the gas insulated equipment 1, and the adsorbent for decomposed gas removal, the embodiment is characterized by enclosing an adsorbent mixture with 5Å and 10Å Zeolites.

As for the ratio of the adsorbent with 5Å and 10Å Zeolites, it is desirable that the former becomes more than 80wt% and the latter becomes less than 20wt%.

The quantity of SO_2F_2 generated is small compared with SOF_2 generated, and it is known that it is ordinarily 1/10 or less. In this embodiment, the adsorbent has two types, approximately 5Å size and 10Å size of pores in the gas-insulated equipment 1, according to the above-mentioned ratio.

The quantity of SF_6 gas adsorption in the gas insulated equipment 1 can be minimized, while maintaining the adsorption performance of the decomposed gas. That is, SF_6 gas does not escape from the gas-insulated equipment 1 for a long period of time, when reduced

pressure reclaiming is performed. Consequently, reclaiming working hours can be shortened and reclaiming efficiency improved.

According to the present invention, the reclaiming performance of SF₆ gas can be improved by setting the reflux-line and returning the gas in the gas phase in the gas liquefaction system to the mixed gas introduction section. Moreover, according to the present invention, SF₆ gas and other insulated gases are efficiently separable with a unique adsorption action of the adsorbent.

Shortening of reclaiming working hours can be attained by this separation, raising SF₆ gas concentration and raising the reclaiming efficiency under reduced pressure. Furthermore, according to the present invention, longevity of the life of the equipment can be enabled by removing decomposed gas discharged from the gas insulated equipment. Furthermore, the optimization of the combination and ratio in the adsorbent in the gas insulated equipment can be attained, and outstanding reclaiming efficiency can be demonstrated.

Japanese priority Application No. PH 11-282045, filed on October 1 and 1999, including the specification, drawings, claims and abstract, is hereby incorporated by reference.

What is claimed is:

1. A gas reclaiming equipment, which is applied to a gas insulated equipment filled with mixed gas including an insulated gas which has SF₆ gas as an ingredient,

5 comprising:

a filter for removing a decomposed gas and a foreign particulate substance from said mixed gas which is sent from said gas insulated equipment;

a gas liquefaction system for reclaiming said mixed gas, wherein said gas liquefaction system liquefies said SF₆ gas of said mixed gas by pressurizing said mixed gas;

10 a pump for sending said mixed gas from said gas insulated equipment to said gas liquefaction system;

a storage tank for accumulating a SF₆ liquid obtained with said gas liquefaction system; and

15 a line for returning a gas in the gas phase in said gas liquefaction system to an upstream side of said gas liquefaction system.

2. The gas reclaiming equipment according to claim 1, wherein said filter has an adsorbent of a chemisorption type which absorbs said decomposed gas.

3. The gas reclaiming equipment according to claim 1, wherein said gas insulated equipment has an adsorbent having Zeolites with approximately 5Å size and 10Å size, and having a ratio of said Zeolites wherein the 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

4. A gas reclaiming equipment, which is applied to a gas insulated equipment filled with mixed gas including an insulated gas like SF₆ gas, comprising:

25 a first filter for removing a decomposed gas and a foreign particulate substance from said mixed gas which is sent from said gas insulated equipment;

a gas liquefaction system for reclaiming said mixed gas, wherein said gas liquefaction system liquefies said SF₆ gas of said mixed by pressurizing said mixed gas;

a pump for sending said mixed gas from said gas insulated equipment to said gas liquefaction system;

a first storage tank for accumulating a SF₆ liquid obtained by said gas liquefaction system;

a gas separation equipment for separating said SF₆ gas from said mixed gas, and sending said SF₆ gas into said gas liquefaction system, said gas separation equipment provided between said gas insulated equipment and said gas liquefaction system; and

a buffer tank for storing said mixed gas, said buffer tank provided between said gas insulated equipment and said gas separation equipment.

5. The gas reclaiming equipment according to claim 4, wherein said buffer tank has an adsorbent comprising Zeolites with 5Å size and 10Å size.

6. The gas reclaiming equipment according to claim 4, wherein said buffer tank stores said mixed gas when said mixed gas is reclaimed under reduced pressure.

7. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment includes pressure swing adsorption including an adsorbent with selective adsorption.

8. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment has a second filter with a permeable membrane.

9. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment has plural separating units to separate said SF₆ gas from said mixed gas.

10. The gas reclaiming equipment according to claim 4, further comprising: a second storage tank storing a specified gas separated by said gas separation

equipment, said second storage tank including an adsorbent to adsorb said SF₆ gas.

11. The gas reclaiming equipment according to claim 4, wherein said filter has an adsorbent to adsorb said decomposed gas.

12. The gas reclaiming equipment according to claim 4, wherein said gas separation equipment includes an adsorbent having Zeolites with approximately 5Å size and 10Å size, and wherein a ratio of said Zeolites with 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

13. A method of reclaiming insulating gas from a mixed gas of a gas insulated equipment comprising:

flowing the mixed gas through a filter to remove decomposed gas and foreign particulate substances;

flowing the mixed gas to a gas liquefaction system;

liquefying the insulating gas; and

returning gas in the gas phase from the gas liquefaction system to an upstream side of the gas liquefaction system.

14. The method of claim 13, further comprising chemisorbing decomposed gas in said filter.

15. The method of claim 13, further comprising flowing said mixed gas through a gas separation unit.

16. The method of claim 15, wherein said gas separation unit includes an adsorbent having Zeolites with approximately 5Å size and 10Å size, and wherein a ratio of said Zeolites with 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

17. The method of claim 15, further comprising flowing mixed gas from said gas separating equipment to a storage tank.

18. The method of claim 17, wherein said storage tank includes an adsorbent to adsorb decomposed gas.

19. The method of claim 17, wherein said storage tank includes an adsorbent to adsorb SF₆ gas.

5 20. The method of claim 13, further comprising flowing the mixed gas through a buffer tank.

21. The method of claim 20, wherein said buffer tank includes an adsorbent having Zeolites with approximately 5Å size and 10Å size, and wherein a ratio of said Zeolites with 5Å size is more than 80wt% and said Zeolites with 10Å size is less than 20wt%.

ABSTRACT OF THE DISCLOSURE

A gas reclaiming equipment capable of separating SF₆ gas from a mixed gas efficiently and shortening reclaiming work under reduced pressure. A gas separation equipment is provided between a gas insulated equipment and a gas liquefaction system. The gas separation equipment separates nitrogen gas from the mixed gas, and concentrates SF₆ gas. Only SF₆ gas is sent into the gas liquefaction system. The gas separation equipment uses pressure swing adsorption using an adsorbent with selective adsorption. Moreover, a buffer tank for storing mixed gas is provided between the gas separation equipment and the gas insulated equipment. The buffer tank and the gas liquefaction system are connected by a reflux-line. The reflux-line refluxes the gas in a gas phase in the gas liquefaction system to the buffer tank. Furthermore, the gas separation equipment is connected to a storage tank. The storage tank accumulates the nitrogen gas separated with the gas separation equipment. The adsorbent to adsorb SF₆ gas is enclosed in the storage tank for exhaust gas. To absorb decomposed gas, the filter has an adsorbent of the chemisorption type. The adsorbent has of a metal hydrate.

Fig. 8

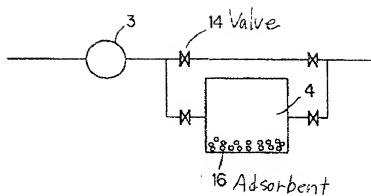


Fig. 1

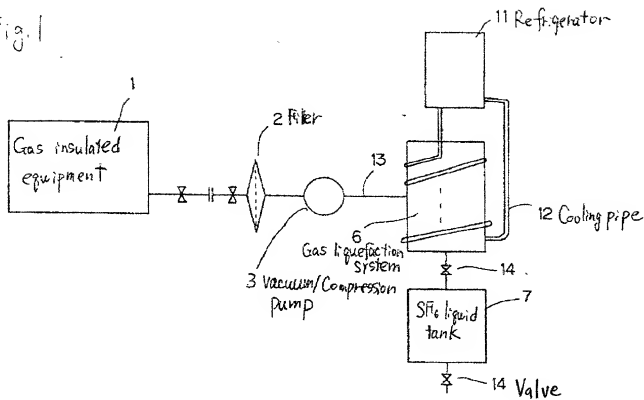


Fig. 3

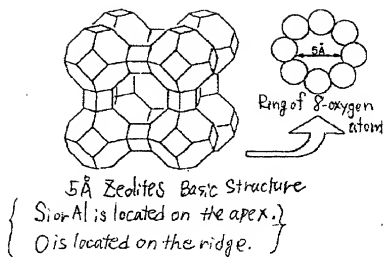


Fig. 10

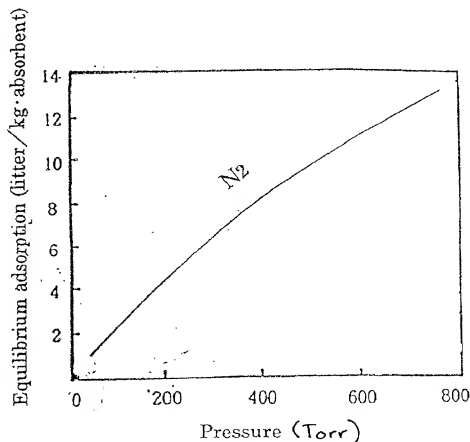
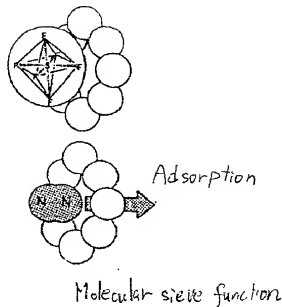


Fig. 4

Equilibrium adsorption vs Pressure (zeolite type 4~5Å)

Fig. 5

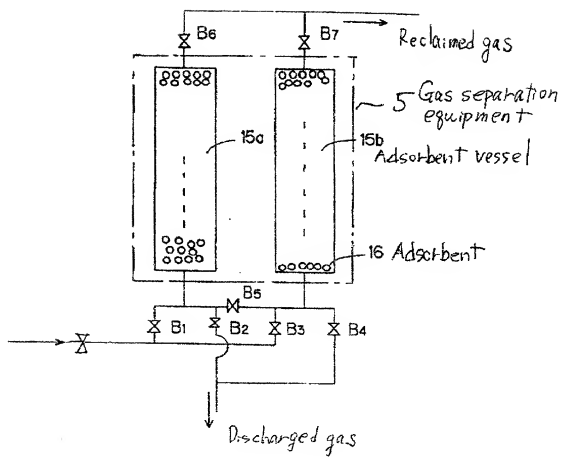
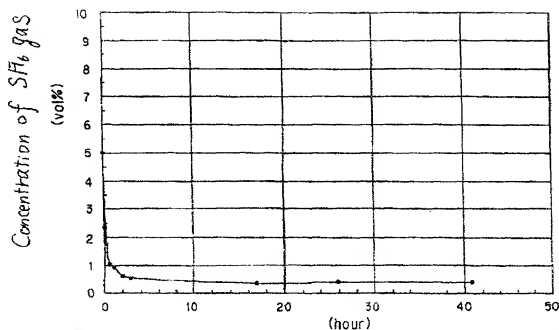
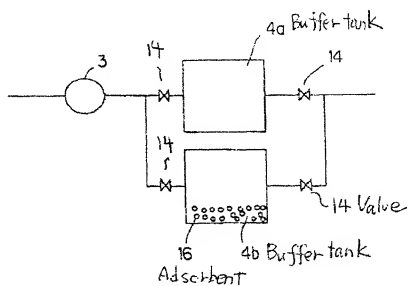


Fig. 6



Adsorption Characteristic of 10 Å Zeolites

Fig. 7



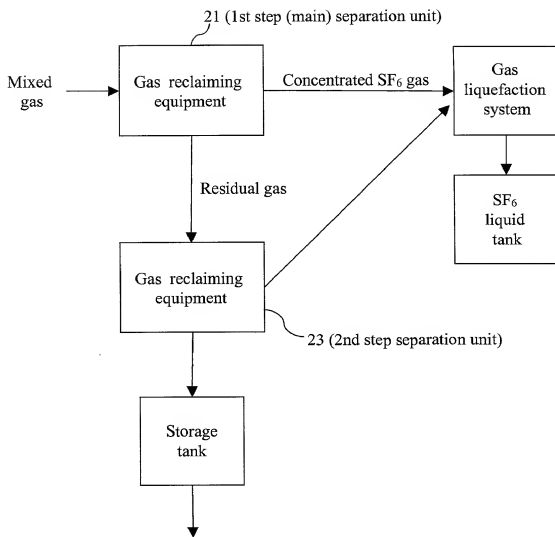


Fig.9

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I HEREBY DECLARE:

THAT my residence, post office address, and citizenship are as stated below next to my name;

THAT I believe I am the original, first, and sole inventor (if only one inventor is named below) or an original, first, and joint inventor (if plural inventors are named below or in an attached Declaration) of the subject matter which is claimed and for which a patent is sought on the invention entitled

GAS RECLAIMING EQUIPMENT

(Attorney Docket No. 016910/0467)

the specification of which (check one)

☐ is attached hereto.

☒ was filed on September 29, 2000 as United States Application Number or PCT International Application Number _____ and was amended on _____ (if applicable).

THAT I do not know and do not believe that the same invention was ever known or used by others in the United States of America, or was patented or described in any printed publication in any country, before I (we) invented it;

THAT I do not know and do not believe that the same invention was patented or described in any printed publication in any country, or in public use or on sale in the United States of America, for more than one year prior to the filing date of this United States application;

THAT I do not know and do not believe that the same invention was first patented or made the subject of an inventor's certificate that issued in any country foreign to the United States of America before the filing date of this United States application if the foreign application was filed by me (us), or by my (our) legal representatives or assigns, more than twelve months (six months for design patents) prior to the filing date of this United States application;

THAT I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment specifically referred to above;

THAT I believe that the above-identified specification contains a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the invention, and sets forth the best mode contemplated by me of carrying out the invention; and

THAT I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I HEREBY CLAIM foreign priority benefits under Title 35, United States Code § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number	Country	Foreign Filing Date	Priority Claimed?	Certified Copy Attached?
11-282045	JAPAN	1 OCTOBER 1999	YES	

I HEREBY CLAIM the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below.

U.S. Provisional Application Number	Filing Date

I HEREBY CLAIM the benefit under Title 35, United States Code, § 120 of any United States application(s), or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application Number	PCT Parent Application Number	Parent Filing Date	Parent Patent Number

I HEREBY APPOINT the following registered attorneys and agents of the law firm of FOLEY & LARDNER to have full power to prosecute this application and any continuations, divisions, reissues, and reexaminations thereof, to receive the patent, and to transact all business in the United States Patent and Trademark Office connected therewith:

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I UNDERSTAND AND AGREE THAT the foregoing attorneys and agents appointed by me to prosecute this application do not personally represent me or my legal interests, but instead represent the interests of the legal owner(s) of the invention described in this application.

I FURTHER DECLARE THAT all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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